F-2

DAVINROY

EMAIL RE: FLOW VISUALIZATION AND FLOW PATHS

Gaines, Roger A MVM

From: Gaines, Roger A MVM
Sent: Friday, August 16, 2002 7:46 AM
To: Davinroy, Robert D MVS
Subject: RE: Ice Photos

Rob,

Just had this follow-up thought. Looking at the questions I raised in last (4:08 pm) email of yesterday made me think of how we can consider the question of model usage -- I see that as one aspect of the "limitations" issue we are discussing.

Would you consider the 0.6 inch wide channel in the same way as you would one that was 4 inches wide, or 12 inches wide? If the answer is yes, then why aren't all micromodels constructed with channels 0.6 inches wide? As developer of the micromodel approach, would you think that channel size plays any role in what you can expect from the model? If so, what role does choosing a smaller or larger channel width play in what the model result can achieve relative to the prototype? If not, why would we consider using larger channels when something smaller would do the same job?

I have my own ideas about these, but think about it and we'll discuss further.

Andy

-----Original Message-----
From: Davinroy, Robert D MVS
Sent: Thursday, August 15, 2002 4:22 PM
To: Gaines, Roger A MVM
Subject: RE: Ice Photos

I guess I am not communicating very well....the point I was trying to make is that a channel this small can still produce exceptional bed forms..just because it is small doesn't mean it's going to be two-dimensional in it's nature...For you to make conclusions that smaller scales will tend to be more two-dimensional and that bed forms will be harder and harder to develop is not supported by observations seen in this very small channel. The bed was not re-circulating, but it still did developed on its own, there was no molding going on, just an intial homogenous bed profile put in initially....yes, there were surface tension problems at the stucture, but we overcame them....I'll talk to you more tomorrow about this when I get in...gotta go home..talk to you tomorrow, Rob

-----Original Message-----
From: Gaines, Roger A MVM
Sent: Thursday, August 15, 2002 4:08 PM
To: Davinroy, Robert D MVS
Subject: RE: Ice Photos

Rob,

I recall quite a lot about this particular model study because its the one you used in teaching me about the micromodel technology. There are several major differences in this channel and what we do in the "normal" micromodel approach. First, this channel was formed not by sediment recirculation, but by feeding sediment (though the feeding mechanism was not very sophistocated) into the head of the channel. Second, there were noticable surface tension effects at the weir -- these had to be dealt with each and every time the Wolf R.

Gaines, Roger A MVM

From: Gaines, Roger A MVM
ent: Friday, August 16, 2002 7:34 AM
: Davinroy, Robert D MVS
ıbject: RE: Ice Photos

Rob,

I think I see where you are coming from, maybe I'm not communicating all that good either. And lest there be any misunderstanding regarding my earlier remarks about my "experiments" in the sand stream, I was attempting to illustrate some of what you are talking about. That is, I could use the sand stream to demonstrate the processes of scour and deposition -- make a sinuous channel and point bars, deep pools and shallow crossings develop, but I could not take that very far in saying that it was a model that replicated details at prototype scale. For that example, there were no attempts to calibrate anything, just to observe processes. The sand model did a pretty good job at that. I think that is where you are coming from with the Wolf River discussion. I'd agree that the processes exhibited in the Wolf channel resembled what you would expect (or find) in the prototype Wolf.

The main difference in what my flume conclusions discuss and what I think you are driving at relates to the use of surface flow patterns. The wall boundary layer does have an impact on how structures in the model affect flow distributions (surface and cross-sectional). My main focus in the flume conclusions is on surface flow patterns. Although the scour and deposition observed in the small channel appear to mimic the processes at prototype scale, the small channel does not necessarily exhibit the same surface flow patterns because the bed develops as a result of distortions in the hydraulic characteristics -- geometrical distortion via the vertical scale greater than the horizontal scale and energy distortion that is necessary to increase the level of energy in the model flow to move the sediments in a manner consistent with observed scour and deposition trends. The energy distortion results from increasing the slope and an overall reduction in the friction (or roughness) characteristics. Without the increased energy in the model channel, the bed would not develop properly.

I realize that the "small streams are models of larger streams" concept is founded on real-world observations. However, I'd add that this pertains essentially to the scour and deposition patterns (bed development) and not to the surface flow patterns nor to the flow distribution. Think about what the surface currents seen in a small tributary look like compared to a large river. Often there is a much greater superelevation around bends and even deflection of the highest thread of velocity from bank to bank. Would you argue that a stream like Big Creek would have the same surface velocity patterns the MS River? Would your answer vary from local to far field patterns? For one thing, isn't Big Creek more sinuous ın the MS?

Although the small channels may exhibit sedimentation trends that we think are right, this is achieved at a price -- we tilt the model to get this to happen and we don't provide a commensurate change in sinuosity or other flow characteristics like roughness that would be found in smaller streams relative to the large channels we are modeling (we use the same sinuosity, scaled of course by the horizontal scales, found in the prototype and we don't do anything to adjust for friction/roughness). Higher velocities (and Froude number) in the small channels tend to follow a different trace than would the prototype. Boundary effects (from both walls/banks and the bottom) tend to have a greater influence on smaller channels than on larger channels. Consider a logrithmic velocity distribution from the bed to the water surface, the most rapidly changing part of this curve (near the bed) is influenced by the boundary layer thickness. The same holds true for a velocity distribution referenced perpendicular to the wall/bank -- the most rapidly changing part of this curve (this time nearest to the bank) is influenced by the boundary layer that develops largely as a function of the sediment particle size in the model channels. These boundary layers in the model channel occupy a much greater portion of the flow cross-section than occurs at prototype scale.

Just to make you aware, I am having this type of discussions with Steve on other issues. As you know, my opinions may not be the same as yours on some areas. That does not mean that I am against micromodeling -- quite the opposite is true, they have their place. Contrary to what one may think, my views don't necessarily agree with all of Steve's view points either. We all have our individual points of view, somehow we have to make things come together as best as we can (and very soon too!).

Andy

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From: Davinroy, Robert D MVS
Sent: Thursday, August 15, 2002 4:22 PM
To: Gaines, Roger A MVM
Subject: RE: Ice Photos

I guess I am not communicating very well....the point I was trying to make is that a channel this small can still produce exceptional bed forms..just because it is small doesn't mean it's going to be two-dimensional in it's nature...For you to make conclusions that smaller scales will tend to be more two-dimensional and that bed forms will be harder and harder to develop is not supported by observations seen in this very small channel. The bed was not re-circulating, but it still did developed on its own, there was no molding going on, just an intial homogenous bed profile put in initially....yes, there were surface tension problems at the stucture, but we overcame them....I'll talk to you more tomorrow about this when I get in...gotta go home..talk to you tomorrow, Rob

-----Original Message-----
From: Gaines, Roger A MVM
Sent: Thursday, August 15, 2002 4:08 PM
To: Davinroy, Robert D MVS
Subject: RE: Ice Photos

Rob,

I recall quite a lot about this particular model study because its the one you used in teaching me about the micromodel technology. There are several major differences in this channel and what we do in the "normal" micromodel approach. First, this channel was formed not by sediment recirculation, but by feeding sediment (though the feeding mechanism was not very sophistocated) into the head of the channel. Second, there were noticable surface tension effects at the weir -- these had to be dealt with each and every time the Wolf R. channel flow was introduced (as I recall a dental pick or pencil had to be used in breaking the minuscus that formed at the weir crest to prevent flow being concentrated at a single narrow point). Third, what was the flow visualization used for? Wasn't it just to see how the flow exited the Wolf? There wasn't any prototype data to confirm (or deny) what was going on. We used some external calculations I made to check the amount of sediment being deposited in the harbor.

Flows in this channel were extremely small and (from memory) only covered the point bar features. There were no training structures used, nor were there uses for the flow visualization anywhere except to see how the flow exited the realigned harbor. We did attempt to make adjustments in the Wolf channel to "calibrate" to some limited survey data, but the model did not include any semblance of the backwater effects often found in the river (we did pool the MS a couple of time as I recall). I believe we even had discussions about how the Wolf River channel had a different time scale relative to the MS portion of the model and that maybe the vertical scales should also be different. Except for the surveying and Microstation parts of this work, it wasn't much different that what I had done years ago in a sand ditch on our farm. Does that mean that I was doing micromodeling then?

Would you classify this channel in the same realm as the Vicksburg model or the Marquette Chute model? How about others? Would you admit that this "model" of the Wolf River had limitations in what could be reasonably expected from any results? How would those limitations compare to other micromodels?

Andy

-----Original Message-----
From: Davinroy, Robert D MVS
Sent: Thursday, August 15, 2002 3:05 PM
To: Gaines, Roger A MVM
Subject: RE: Ice Photos

Andy,
Andy, Thanks for the input. this might answere some of your questions. Attached are two more photos for you to think about, this shows pretty darn good bed patterns in a channel with an average width of .6 inches (slightly 1 inch in bend) and also shows flow visualization. Comments are always appreciated, thanks, Rob

<< File: WolfDoc.doc >>

-----Original Message-----
From: Gaines, Roger A MVM
Sent: Thursday, August 15, 2002 2:28 PM
To: Davinroy, Robert D MVS
Subject: RE: Ice Photos

Rob,

I have studied the two images you provided. Here is what I see from the ice floes. NOTE: measurements I've made are based on assuming the printed images are at true scale -- there is no scale bar to verify this, but the widths of 1600 ft. seem consistent with the Nav charts and what I've heard for this reach of the Upper MS River.

<u>Figure 1</u> (photo has no label shown) -- ~RM135.
average flow width approx. 1600-1750 ft.

separation between RDB and ice trace: 250 ft. to 350 ft. max (center if image) to ~150 ft. (lower 1/3 of image). Ice trace follows a nearly straight line from upper edge of the photo to about 9500 feet downstream -- where the leftward bend in the channel occurs. Bank in the area sags behind a line projected along a "smooth" line of curvature.

separation between LDB and ice trace (this is heavily influenced by the contraction imposed by a long sequence of relatively closely space dikes): ~ 0 to 100 ft. from dike ends

Bank alignment and bank slope have an influence on how closely the main thread of velocity (defined by the ice floe) approaches the water's edge.

The barge (looks like a barge in the upper part of the photo, but image is pixelated so identity unknown) significantly influences the position of the ice trace over the upper 1/2 of the image along the RDB.

Figure 2 (photo is labeled 1-16-99 STL 2-something) -- mouth of Kaskaskia River reach

average flow width approx. 1600 ft.

separation between RDB and ice trace: ~150-250 feet from end of dikes. ~ 150 feet from RDB at upper edge of image. Separation heavily influenced by the contraction imposed by the long sequence of dikes along this bank. The sag in the bank line ~350 ft. from top of image also seems to have a major influence on the position of the ice floe.

separation between LDB and ice trace: Except in lower 1/3 of image, the ice seems to hug the bank. Although there is only a minimal amount of ice along this bank, its presence adjacent to the bank indicates very little boundary influence. The deflection of the ice trace near the lower edge of the photo (just upstream of the Kaskaskia River is influenced by a feature that cannot be determined at this image resolution/scale -- perhaps it is a boat tied up at this point. Position of the ice flow at and below the Kaskaskia River are influenced by the tributary outflow (suggested by the surface irregularities in the tributary).

Conclusions:

Ice floe trace is somewhat different than continuous seeding across the entire channel width.

Natural irregularities along the channel bank influence the location and extent of boundary layer along the bank itself.

The presence of dikes along the bank produces a different boundary effect than discussed in flume conclusions. The boundary effects off the ends of dikes as seen in the two photos are almost entirely due to flow shedding off the ends of the dikes.

Bank and channel alignment have an impact on the extent of the side boundary layer development. This is particularly apparent in the first photo. Obviously, the flumes have straight uniform banks. Flume walls are also smoother than exists in model inserts.

The sloped banks in the prototype also influence the extent of the side boundary layer. Based on depths of about 20-30 feet and bank slopes of 2.5:1 or greater, the toe of the bank extends about 150 feet from the water's edge. Coincidentally, this is about where the ice floe trace is located. This is part of the difference between the flume information and what the real prototype cross-section experiences. The model falls somewhere between, because some of the model banks are replicated in a vertical manner (like the flumes) and some have a slope. Those model areas that have a slope are still different than the prototype because the small flow depths relative to the channel width result in some surface tension effects (observed from the curvature in the water surface at the banks) and an increased bed roughness -- both of which tend to increase the "wall" boundary layer effect.

While the sloped and irregular banks in the model may partially mitigate some of the "wall" boundary effects, they are still present. These boundary effects also have a greater influence on the model channel than anything found in the prototype. The separation distances estimated in the two photos represent up to about 10 percent of the flow width. This does not include the measurements influenced by the dikes which induce additional turbulent boundary effects that would dominate any boundary effects realized at or near the water's edge (in the presence of dikes). Even disregarding the influence of the tow in photo 1 on the position of the ice flow, the 250 ft. separation represents only 15 percent of the total width.

Observations from the flume experiments indicate that the wall boundary layer remains about the same physical dimension between the three channels (about 1/3 inch). Clearly, a 1/3 inch boundary layer in the 2-inch width has a much greater impact on the flow than does a 1/3 inch boundary layer in the 6-inch and 12-inch flumes. This 1/3 inch translates into 17 percent of the total flow width. Allowing for both banks/walls, the figures have approximately 23 percent of the MS River channel width represented in the separation region. Compare this to using the .33 inch boundary layer width for each wall in the 2-inch flume (total of .667 inches) which represents 33 percent. Is this significant? I see the ice floe traces to demonstrate different information than seen in the seeded flow in the flumes. The fact that the 1/3-inch wall boundary in the flumes was consistent for the length of the flumes points to one major difference -- no effect of channel alignment or other disturbances along the bank were included.

The argument that the model would show the same effect found in the prototype is only partially valid -- it depends greatly on the model in question. Can you tell me whether the White River models (Clarendon and Augusta) behaved more like a flume or more like the prototype? These models had the banks largely defined by the vertical walls of the insert with few areas defined by bottom elevations [i.e. sloped banks] that exceeded the low flow water surface. If there was a 1/3 inch wide boundary layer along each of the walls, this would translate into 44 percent of the channel width (assuming channel width ~ 1.5 inches) accounting for both walls. Even if the boundary layer width was only one half of this, it would still be 22 percent of the channel width. Dike lengths used in the these two White River models were only about 1/3 to 1/2 inch long. Do you think that the boundary layer induced by the wall had no influence on flow patterns at those dikes? Granted that flow visualization was not a major part of the WR models, but do you think you could achieve the same results using flow visualization in the 1.5 inch wide channel as you could in a channel of 3-inches, 6-inches, or even 12-inches? What confidence did you place in the projected scour patterns in the 1.5 inch wide channels compared to confidence placed in projected scour patterns for channels having 4 to 5 inch or greater widths?

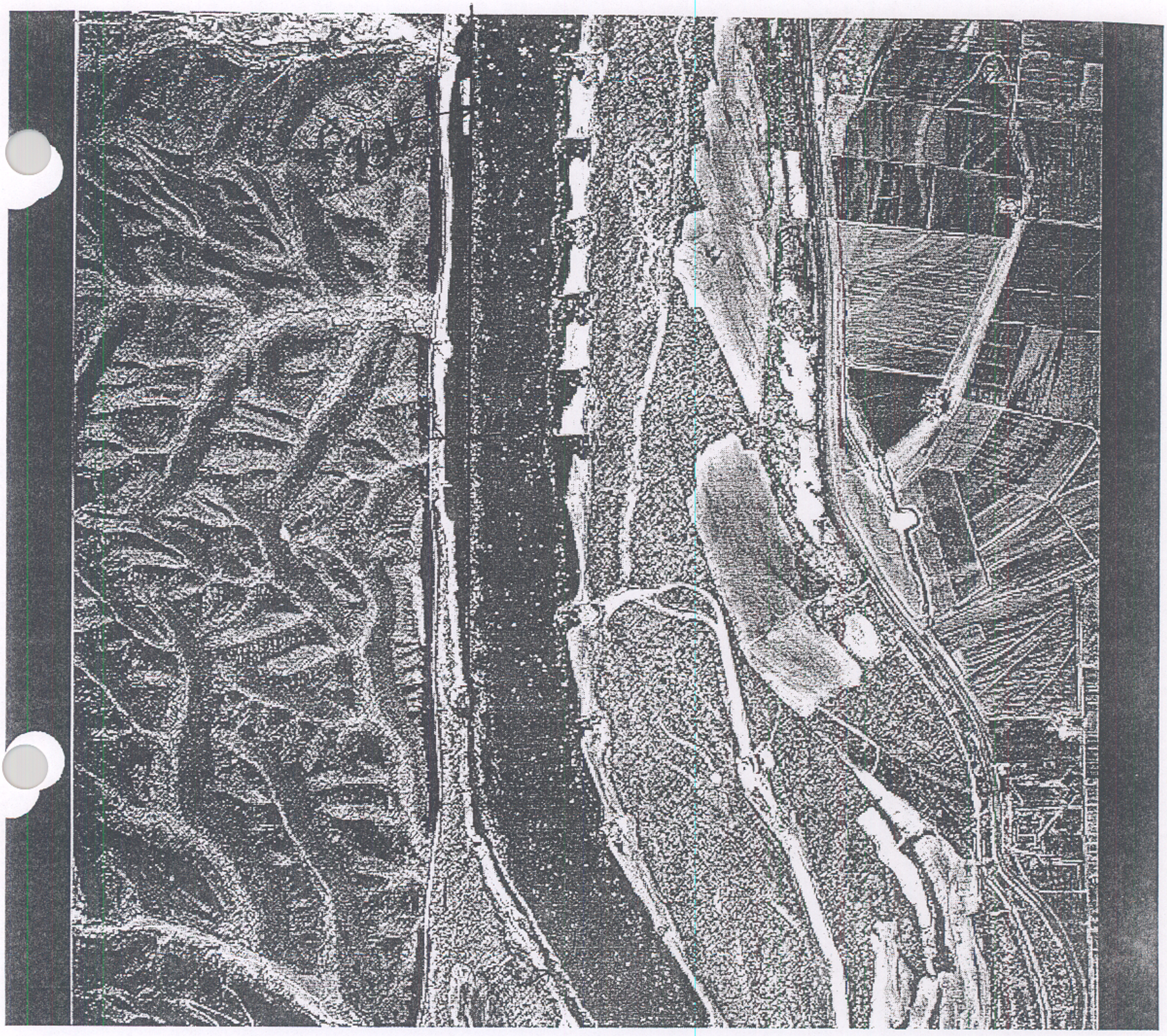
Andy

-----Original Message-----
From: Davinroy, Robert D MVS
Sent: Wednesday, August 14, 2002 1:41 PM
To: Gaines, Roger A MVM
Cc: Gordon, David MVS
Subject: Ice Photos

Andy,
I have read your flow visualizations experiments at Rolla and conclusions. Before I spend anytime writing my comments, please view these two ice photos of the Mississippi River. The scale of the original photos is 1inch= 2000 feet. Direction of flow is from the top to the bottom of each photo.

Please study the boundary effects produced by the prototype on the flowing ice. After viewing these photos, would your conclusions about boundary affects of the models still be the same? Let me know, thanks, Rob

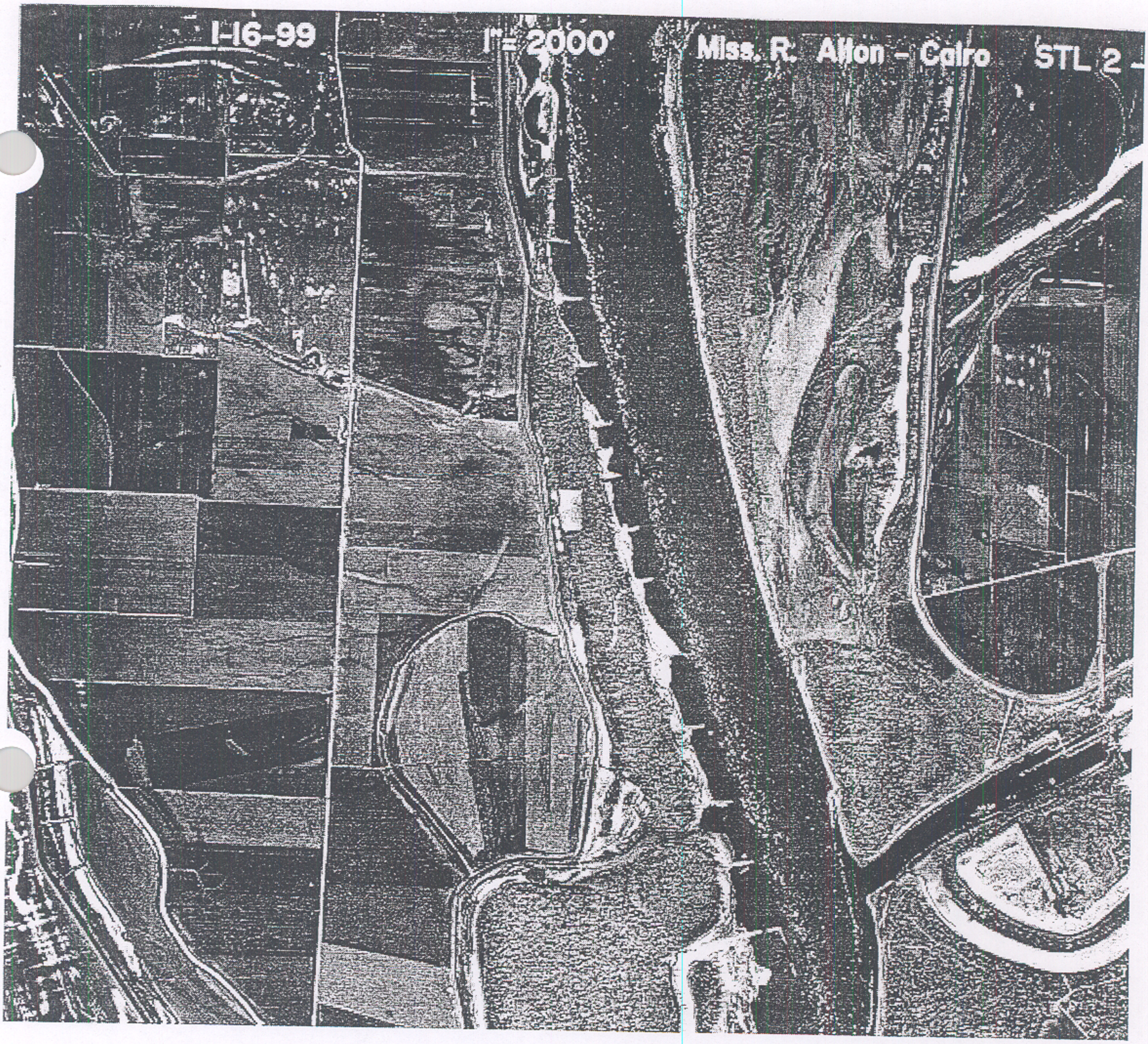
<< File: Miss1.tif >> << File: Miss2.tif >>



MISS12.tif

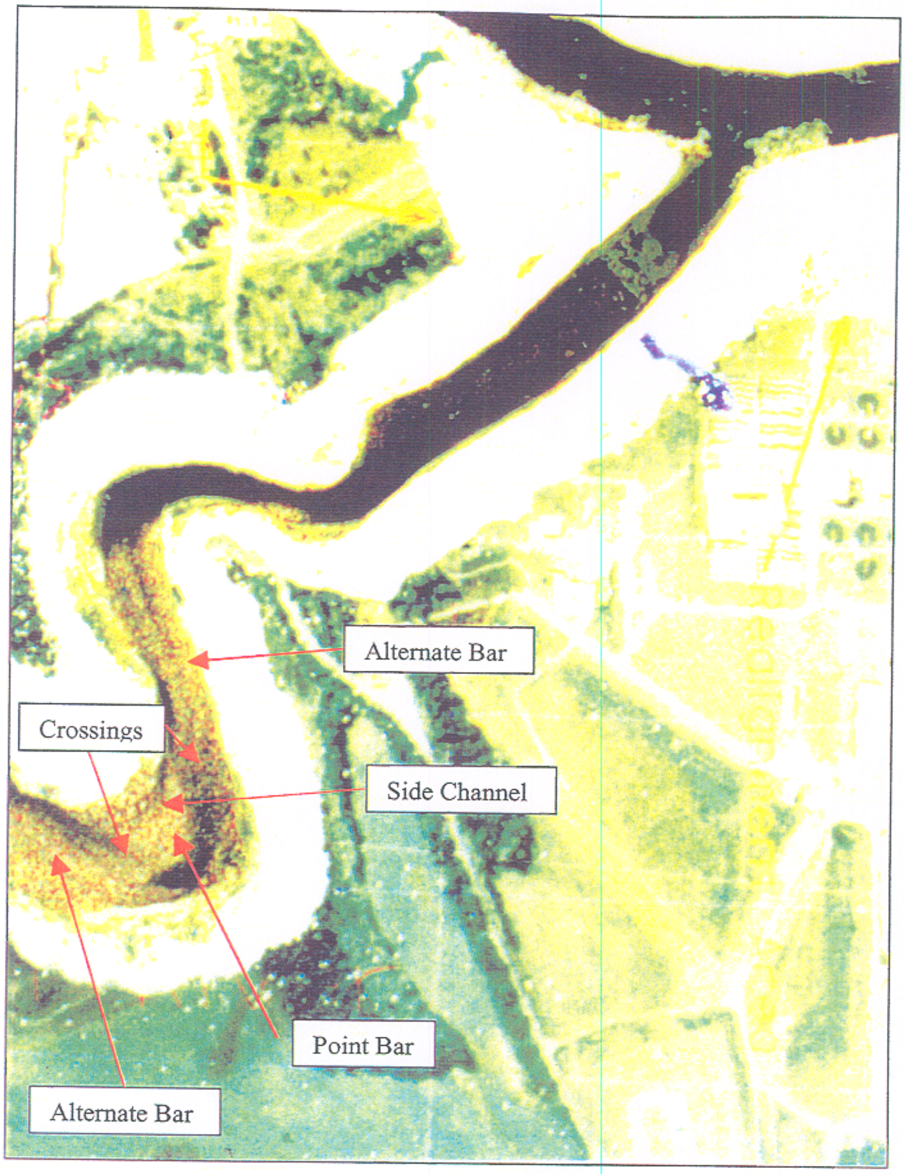
~ width ~ 1600'

Nav Chart #17



Miss2.tif

Nav Chart #19


Alternate Bar
Crossings
Side Channel
Point Bar
Alternate Bar